

WHAT IS CLAIMED:

1. A method for defibrillating a heart in fibrillation, comprising:
detecting fibrillation of the heart; and
applying a defibrillation stimulus to a fastest activating region of the
5 fibrillating heart.
2. A method according to Claim 1 wherein the fastest activating region
comprises a reentrant region having a refractory period that is less than areas adjacent
to the reentrant region.
- 10 3. A method according to Claim 1 wherein a first wavefront propagates
along a closed pathway on the fibrillating heart, wherein the first wavefront generates
at least a second wavefront that propagates on the fibrillating heart outside the fastest
activating region.
- 15 4. A method according to Claim 1 wherein the fastest region comprises a
closed pathway on the fibrillating heart.
5. A method according to Claim 4 wherein a wavefront propagates along
20 the closed pathway from a starting point on the closed pathway to an ending point on
the closed pathway.
6. A method according to Claim 5 wherein the starting point and the
ending point are adjacent to one another on the closed pathway.
- 25 7. A method according to Claim 1:
wherein the fibrillation comprises atrial fibrillation; and
wherein the fastest activating region comprises at least one of adjacent to
pulmonary veins of the fibrillating heart and between the pulmonary veins and a left
30 atrial appendage of the fibrillating heart.
8. A method according to Claim 1:
wherein the fibrillation comprises ventricular fibrillation; and

wherein the fastest activating region comprises a base of a left ventricle of the fibrillating heart.

9. A method according to Claim 1:
5 wherein the fibrillation comprises ventricular fibrillation; and
wherein the fastest activating region comprises a septum of the fibrillating heart.

10. A method according to Claim 1 wherein applying comprises applying a
10 first defibrillation stimulus at least one of before, during, or after a second
defibrillation stimulus that is greater than the first defibrillation stimulus.

11. A method according to Claim 10 wherein at least one of the first and
second defibrillation stimuli is applied using at least a pair of electrodes, wherein the
15 pair of electrodes is located one of:
inside the fastest activating region;
outside the fastest activating region; and
a first electrode of the pair of electrodes is inside the fastest activating region
and a second electrode of the pair of electrodes is outside the fastest activating region.

20 12. A method according to Claim 1 wherein the defibrillation stimulus is
applied using a pair of electrodes, wherein the pair of electrodes is located one of:
inside the fastest activating region;
outside the fastest activating region; and
25 a first electrode of the pair of electrodes is inside the fastest activating region
and a second electrode of the pair of electrodes is outside the fastest activating region.

13. A method according to Claim 1 further comprising:
applying at least one pacing stimulus to the fastest activating region
30 simultaneously with the defibrillation stimulus.

14. A method according to Claim 1 further comprising:
applying at least one pacing stimulus to the fastest activating region
immediately before or after the defibrillation stimulus.

15. A method according to Claim 1 further comprising:
applying at least one first pacing stimulus at the fastest activating region at least one
of before, simultaneous with, or after the defibrillation stimulus; and
5 applying at least one second pacing stimulus to the fibrillating heart at a location
spaced-apart from the fastest activating region.

16. A method according to Claim 16 wherein the at least one second
pacing stimulus is applied using at least one line electrode.

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17. A method according to Claim 1 wherein the fastest activating region
comprises the septum.

18. A method according to Claim 1 wherein a location of the fastest
15 activating region is determined by:
determining a monophasic activation potential (MAP) reading associated with
the fibrillating heart.

19. A method for reducing an occurrence of fibrillation of a heart,
20 comprising:
detecting a premature contraction of the heart for a plurality of heart beats
characterized by nonsustained tachycardia; and
applying an electric stimulus to a region of the heart that is likely to contain a
fastest activating region.

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20. A method according to Claim 19 wherein the electric stimulus
comprises one of a defibrillation stimulus and a pacing stimulus.

21. A method according to Claim 19 wherein a location of the fastest
30 activating region is determined by:
inducing fibrillation of the heart; and
determining at least one of a monophasic activation potential (MAP) reading
associated with the fibrillating heart, a refractory period associated with the heart

using premature stimulation, and a power spectrum analysis to provide a spectrum with a peak power at a highest frequency.

22. A method according to Claim 19 wherein the fastest activating region
5 comprises a reentrant region having a refractory period that is less than areas adjacent to the reentrant region.

23. A method according to Claim 19 wherein a first wavefront propagates
along a closed pathway on the fibrillating heart, wherein the first wavefront generates
10 at least a second wavefront that propagates on the fibrillating heart outside the fastest activating region.

24. A method according to Claim 19 wherein the reentrant region
comprises a closed pathway on the fibrillating heart.
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25. A method according to Claim 24 wherein a wavefront propagates
along the closed pathway from a starting point on the closed pathway to an ending
point on the closed pathway.

20 26. A method according to Claim 25 wherein the starting point and the ending point are adjacent to one another on the closed pathway.

27. A method for reducing an occurrence of fibrillation of a heart,
comprising:
25 during heart activity characterized by at least one of normal heartbeat activity, premature heartbeat activity, or nonsustained tachycardia activity, applying an electrical stimulus to a region of the heart containing a fastest activating region.

28. A method according to Claim 27 wherein the fastest activating region
30 comprises a reentrant region having a refractory period that is less than areas adjacent to the reentrant region.

29. A method according to Claim 27 wherein a first wavefront propagates along a closed pathway on the heart, wherein the first wavefront generates at least a second wavefront that propagates on the heart outside the fastest activating region.

5 30. A method according to Claim 27 wherein the reentrant region comprises a closed pathway on the heart.

31. A method according to Claim 28 wherein a wavefront propagates along the closed pathway from a starting point on the closed pathway to an ending
10 point on the closed pathway.

32. A method according to Claim 29 wherein the starting point and the ending point are adjacent to one another on the closed pathway.

15 33. A method according to Claim 27 wherein a location of the fastest activating region is determined by:
determining a refractory period associated with the heart using premature stimulation.

20 34. A method according to Claim 28 wherein a location of the fastest activating region is determined by:
determining an activation recovery interval measurement associated with the heart.

25 35. A method according to Claim 27 wherein a location of the fastest activating region is determined by:
determining a Monophasic activation potential (MAP) reading of the heart.

30 36. A method according to Claim 27 wherein a location of the fastest activating region is determined by:
inducing fibrillation of the heart; and
determining at least one of a monophasic activation potential (MAP) reading associated with the fibrillating heart, a refractory period associated with the heart

using premature stimulation, and a power spectrum analysis to provide a spectrum with a peak power at a highest frequency.

5 37. A system for defibrillating a heart in fibrillation, comprising:
 means for detecting fibrillation of the heart; and
 means for applying a defibrillation stimulus to a fastest activating region of the
fibrillating heart.

10 38. A system according to Claim 37 wherein the fastest activating region
comprises a reentrant region having a refractory period that is less than areas adjacent
to the reentrant region.

15 39. A system according to Claim 37 wherein a first wavefront propagates
along a closed pathway on the fibrillating heart, wherein the first wavefront generates
at least a second wavefront that propagates on the fibrillating heart outside the fastest
activating region.

20 40. A system according to Claim 37 wherein the fastest region comprises a
closed pathway on the fibrillating heart.

 41. A system according to Claim 38 wherein a wavefront propagates along
the closed pathway from a starting point on the closed pathway to an ending point on
the closed pathway.

25 42. A system according to Claim 41 wherein the starting point and the
ending point are adjacent to one another on the closed pathway.

30 43. A system according to Claim 37:
 wherein the fibrillation comprises atrial fibrillation; and
 wherein the fastest activating region comprises at least one of adjacent to
pulmonary veins of the fibrillating heart and between the pulmonary veins and a left
atrial appendage of the fibrillating heart.

 44. A system according to Claim 37:

wherein the fibrillation comprises ventricular fibrillation; and
wherein the fastest activating region comprises a base of a left ventricle of the
fibrillating heart.

5 45. A system according to Claim 37:
 wherein the fibrillation comprises ventricular fibrillation; and
 wherein the fastest activating region comprises a septum of the fibrillating
 heart.

10 46. A system according to Claim 37 wherein the means for applying
 comprises means for applying a first defibrillation stimulus at least one of before,
 during, or after a second defibrillation stimulus that is greater than the first
 defibrillation stimulus.

15 47. A system according to Claim 46 wherein at least one of the first and
 second defibrillation stimuli is applied using at least a pair of electrodes, wherein the
 pair of electrodes is located one of:
 inside the fastest activating region;
 outside the fastest activating region; and
20 a first electrode of the pair of electrodes is inside the fastest activating region
 and a second electrode of the pair of electrodes is outside the fastest activating region.

 48. A method according to Claim 37 wherein the defibrillation stimulus is
 applied using a pair of electrodes, wherein the pair of electrodes is located one of:
25 inside the fastest activating region;
 outside the fastest activating region; and
 a first electrode of the pair of electrodes is inside the fastest activating region
 and a second electrode of the pair of electrodes is outside the fastest activating region.

30 49. A system according to Claim 37 further comprising:
 means for applying at least one pacing stimulus to the fastest activating region
 simultaneously with the defibrillation stimulus.

50. A system according to Claim 37 further comprising:

means for applying at least one pacing stimulus to the fastest activating region immediately before or after the defibrillation stimulus.

51. A system according to Claim 37 further comprising:

5 means for applying at least one first pacing stimulus at the fastest activating region simultaneously with the defibrillation stimulus; and

means for applying at least one second pacing stimulus to the fibrillating heart at a location spaced-apart from the fastest activating region.

10 52. A system according to Claim 51 wherein the at least one second pacing stimulus is applied using at least one line electrode.

53. A system according to Claim 37 wherein the region comprises the septum.

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54. A system according to Claim 37 wherein a location of the fastest activating region is determined by:

determining a Monophasic activation potential (MAP) reading associated with the fibrillating heart.

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55. A system for reducing an occurrence of fibrillation of a heart, comprising:

means for detecting a premature contraction of the heart for a plurality of heart beats characterized by nonsustained tachycardia; and

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means for applying an electrical stimulus to a region of the heart not in fibrillation likely to contain a fastest activating region.

56. A system according to Claim 55 further comprising:

means for inducing fibrillation of the heart; and

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means for determining at least one of a monophasic activation potential (MAP) reading associated with the fibrillating heart, a refractory period associated with the heart using premature stimulation, and a power spectrum analysis to provide a spectrum with a peak power at a highest frequency.

57. A system according to Claim 55 wherein the fastest activating region comprises a reentrant region having a refractory period that is less than areas adjacent to the reentrant region.

5 58. A system according to Claim 55 wherein a first wavefront propagates along a closed pathway on the heart, wherein the first wavefront generates at least a second wavefront that propagates on the heart outside the fastest activating region.

59. A system according to Claim 55 wherein the reentrant region
10 comprises a closed pathway on the heart.

60. A system according to Claim 59 wherein a wavefront propagates along the closed pathway from a starting point on the closed pathway to an ending point on the closed pathway.

15 61. A system according to Claim 60 wherein the starting point and the ending point are adjacent to one another on the closed pathway.

62. A system for reducing an occurrence of fibrillation of a heart,
20 comprising:
means for applying, during fibrillation during heart activity characterized by at least one of normal heartbeat activity, premature heartbeat activity, or nonsustained tachycardia activity, an electrical stimulus to a region of a heart that is likely to contain a fastest activating region of the heart.

25 63. A system according to Claim 62 wherein the fastest activating region comprises a reentrant region having a refractory period that is less than areas adjacent to the reentrant region.

30 64. A system according to Claim 63 wherein a first wavefront propagates along a closed pathway on the fibrillating heart, wherein the first wavefront generates at least a second wavefront that propagates on the heart outside the fastest activating region.

65. A system according to Claim 62 wherein the reentrant region comprises a closed pathway on the heart.

66. A system according to Claim 65 wherein a wavefront propagates along the closed pathway from a starting point on the closed pathway to an ending point on the closed pathway.

67. A system according to Claim 66 wherein the starting point and the ending point are adjacent to one another on the closed pathway.

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68. A system according to Claim 62 further comprising:
means for determining a refractory period associated with the heart using premature stimulation.

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69. A system according to Claim 62 further comprising:
means for determining an activation recovery interval measurement associated with the heart.

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70. A system according to Claim 62 further comprising:
determining a Monophasic activation potential (MAP) reading of the heart.

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71. A system according to Claim 62 further comprising:
means for inducing fibrillation of the heart; and
means for determining a refractory period associated with the heart using premature stimulation.

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72. A system according to Claim 62 further comprising:
means for inducing fibrillation of the heart; and
means for determining at least one of a monophasic activation potential (MAP) reading associated with the fibrillating heart, a refractory period associated with the heart using premature stimulation, and a power spectrum analysis to provide a spectrum with a peak power at a highest frequency.

73. A computer program product for defibrillating a heart in fibrillation, comprising:

a computer readable medium having computer readable program code embodied therein, the computer readable program code comprising:

5 computer readable program code configured to detect fibrillation of the heart;

and

computer readable program code configured to apply a defibrillation stimulus to a fastest activating region of the fibrillating heart.

10 74. A computer program product according to Claim 73 wherein the fastest activating region comprises a reentrant region having a refractory period that is less than areas adjacent to the reentrant region.

75. A computer program product according to Claim 73 wherein a first
15 wavefront propagates along a closed pathway on the fibrillating heart, wherein the first wavefront generates at least a second wavefront that propagates on the fibrillating heart outside the fastest activating region.

76. A computer program product according to Claim 73 wherein the fastest
20 region comprises a closed pathway on the fibrillating heart.

77. A computer program product according to Claim 76 wherein a
wavefront propagates along the closed pathway from a starting point on the closed pathway to an ending point on the closed pathway.

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78. A computer program product according to Claim 77 wherein the starting point and the ending point are adjacent to one another on the closed pathway.

79. A computer program product according to Claim 73:
30 wherein the fibrillation comprises atrial fibrillation; and
wherein the fastest activating region comprises at least one of adjacent to pulmonary veins of the fibrillating heart and between the pulmonary veins and a left atrial appendage of the fibrillating heart.

80. A computer program product according to Claim 73:
wherein the fibrillation comprises ventricular fibrillation; and
wherein the fastest activating region comprises a base of a left ventricle of the
fibrillating heart.

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81. A computer program product according to Claim 73:
wherein the fibrillation comprises ventricular fibrillation; and
wherein the fastest activating region comprises a septum of the fibrillating
heart.

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82. A computer program product according to Claim 73 wherein the
computer readable program code configured to apply comprises computer readable
program code configured to apply a first defibrillation stimulus at least one of before,
during, or after a second defibrillation stimulus that is greater than the first
defibrillation stimulus.

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83. A computer program product according to Claim 82 wherein at least
one of the first and second defibrillation stimuli is applied using at least a pair of
electrodes, wherein the pair of electrodes is located one of:
inside the fastest activating region;
outside the fastest activating region; and
a first electrode of the pair of electrodes is inside the fastest activating region
and a second electrode of the pair of electrodes is outside the fastest activating region.

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84. A method according to Claim 73 wherein the defibrillation stimulus is
applied using a pair of electrodes, wherein the pair of electrodes is located one of:
inside the fastest activating region;
outside the fastest activating region; and
a first electrode of the pair of electrodes is inside the fastest activating region
and a second electrode of the pair of electrodes is outside the fastest activating region.

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85. A computer program product according to Claim 73 further
comprising:

computer readable program code configured to apply at least one pacing stimulus to the fastest activating region simultaneously with the defibrillation stimulus.

5 86. A computer program product according to Claim 73 further comprising:

 computer readable program code configured to apply at least one pacing stimulus to the fastest activating region immediately before or after the defibrillation stimulus.

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 87. A computer program product according to Claim 73 further comprising:

 computer readable program code configured to apply at least one first pacing stimulus at the fastest activating region simultaneously with the defibrillation

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stimulus; and

 computer readable program code configured to apply at least one second pacing stimulus to the fibrillating heart at a location spaced-apart from the fastest activating region.

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 88. A computer program product according to Claim 87 wherein the at least one second pacing stimulus is applied using at least one line electrode.

 89. A computer program product according to Claim 73 wherein the region comprises the septum.

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 90. A computer program product according to Claim 73 wherein the computer readable program code configured determine the location of the fastest activating region comprises:

 computer readable program code configured to determine a Monophasic
30 activation potential (MAP) reading associated with the fibrillating heart.

 91. A computer program product for reducing an occurrence of fibrillation of a heart, comprising:

a computer readable medium having computer readable program code embodied therein, the computer readable program code comprising:

computer readable program code configured to detect a premature contraction of the heart for a plurality of heart beats characterized by nonsustained tachycardia;

5 and

computer readable program code configured to apply a defibrillation stimulus to a region of the heart not in fibrillation that is likely to contain a fastest activating region.

10 92. A computer program product according to Claim 91 further comprising computer readable program code configured to determine the region of the heart likely to contain the fastest activating region including:

computer readable program code configured to induce fibrillation of the heart; and

15 computer readable program code configured to determine at least one of a monophasic activation potential (MAP) reading associated with the fibrillating heart, a refractory period associated with the heart using premature stimulation, and a power spectrum analysis to provide a spectrum with a peak power at a highest frequency.

20 93. A computer program product according to Claim 91 wherein the fastest activating region comprises a reentrant region having a refractory period that is less than areas adjacent to the reentrant region.

25 94. A computer program product according to Claim 91 wherein a first wavefront propagates along a closed pathway on the fibrillating heart, wherein the first wavefront generates at least a second wavefront that propagates on the fibrillating heart outside the fastest activating region.

30 95. A computer program product according to Claim 91 wherein the reentrant region comprises a closed pathway on the fibrillating heart.

96. A computer program product according to Claim 95 wherein a wavefront propagates along the closed pathway from a starting point on the closed pathway to an ending point on the closed pathway.

97. A computer program product according to Claim 96 wherein the starting point and the ending point are adjacent to one another on the closed pathway.

5 98. A computer program product for reducing an occurrence of fibrillation of a heart, comprising:

a computer readable medium having computer readable program code embodied therein, the computer readable program code comprising:

10 computer readable program code configured to apply, during heart activity characterized by at least one of normal heartbeat activity, premature heartbeat activity, or nonsustained tachycardia activity, an electrical stimulus to a region of the heart not in fibrillation that is likely to contain a fastest activating region.

15 99. A computer program product according to Claim 98 wherein the fastest activating region comprises a reentrant region having a refractory period that is less than areas adjacent to the reentrant region.

100. A computer program product according to Claim 98 wherein a first wavefront propagates along a closed pathway on the fibrillating heart, wherein the
20 first wavefront generates at least a second wavefront that propagates on the fibrillating heart outside the fastest activating region.

101. A computer program product according to Claim 98 wherein the reentrant region comprises a closed pathway on the fibrillating heart.

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102. A computer program product according to Claim 101 wherein a wavefront propagates along the closed pathway from a starting point on the closed pathway to an ending point on the closed pathway.

30 103. A computer program product according to Claim 102 wherein the starting point and the ending point are adjacent to one another on the closed pathway.

104. A computer program product according to Claim 98 further comprising computer readable program code configured to determine the region of the heart likely to contain the fastest activating region including:

5 computer readable program code configured to determine a refractory period associated with the fibrillating heart using premature stimulation.

105. A computer program product according to Claim 98 further comprising computer readable program code configured to determine the region of the heart likely to contain the fastest activating region including:

10 computer readable program code configured to determine an activation recovery interval measurement associated with the fibrillating heart.

106. A computer program product according to Claim 98 further comprising computer readable program code configured to determine the region of the heart likely to contain the fastest activating region including:

15 computer readable program code configured to determining a Monophasic activation potential (MAP) reading associated with the fibrillating heart.

107. A computer program product according to Claim 98 further comprising computer readable program code configured to determine the region of the heart likely to contain the fastest activating region including:

20 computer readable program code configured to induce fibrillation of the heart; and

25 computer readable program code configured to determine at least one of a monophasic activation potential (MAP) reading associated with the fibrillating heart, a refractory period associated with the heart using premature stimulation, and a power spectrum analysis to provide a spectrum with a peak power at a highest frequency.